Multinomial Processing Tree (MPT) Modeling, Part 2: Application I

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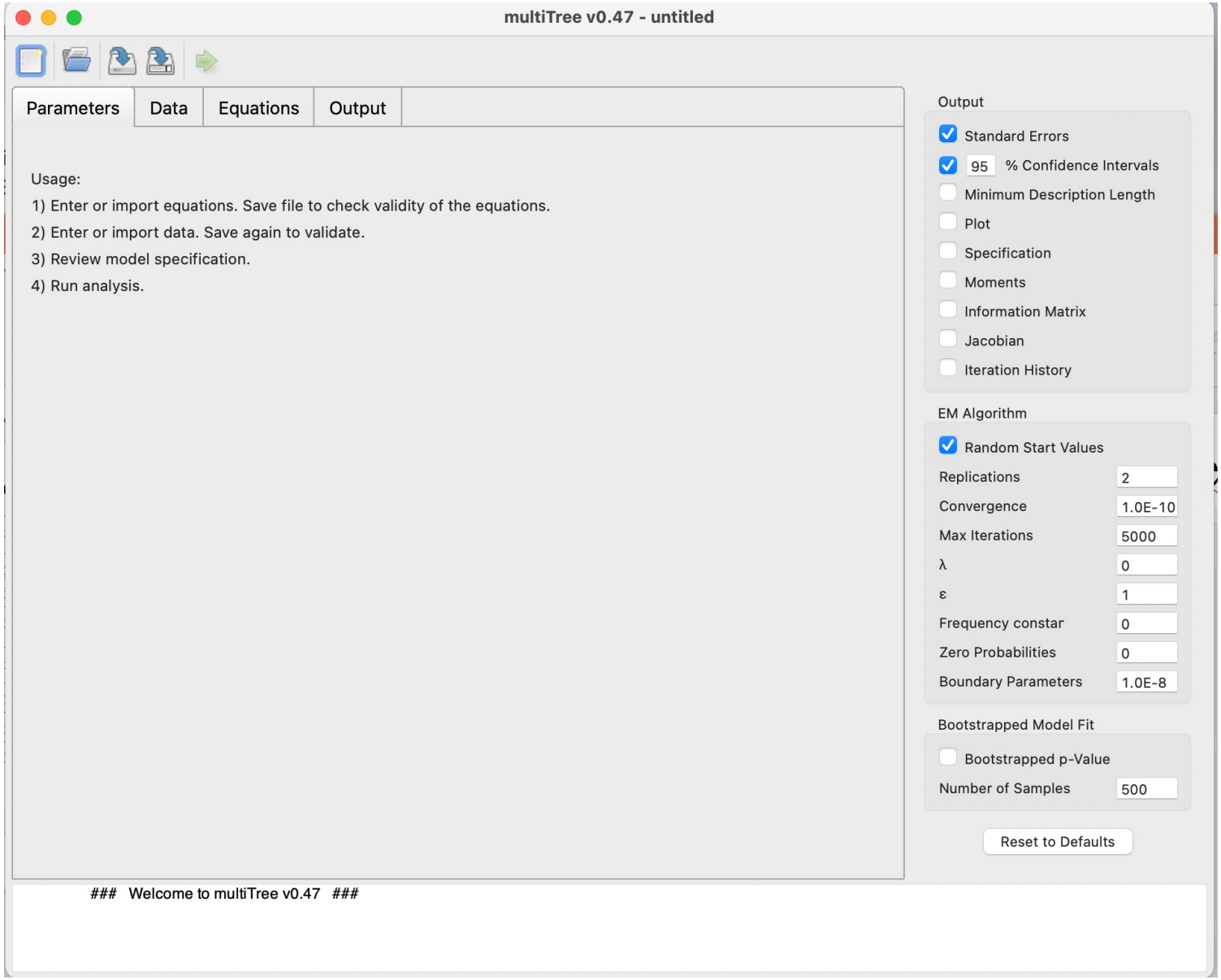
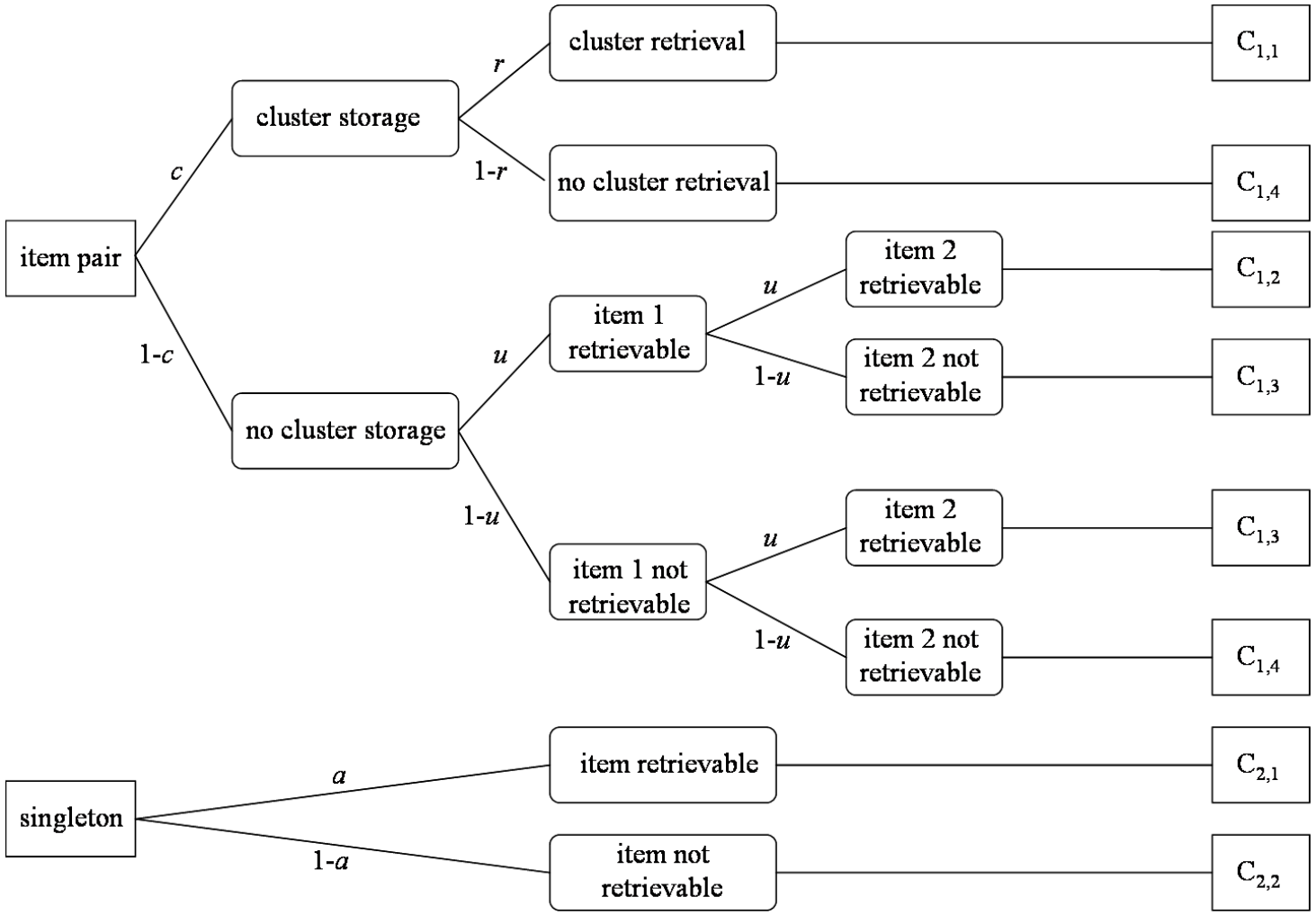
2) Application I

- 2.1) Introduction to multiTree
- 2.2) Practical exercises
- 2.3) Order constraints
- 2.4) Testing interactions

2.1) Introduction to multiTree

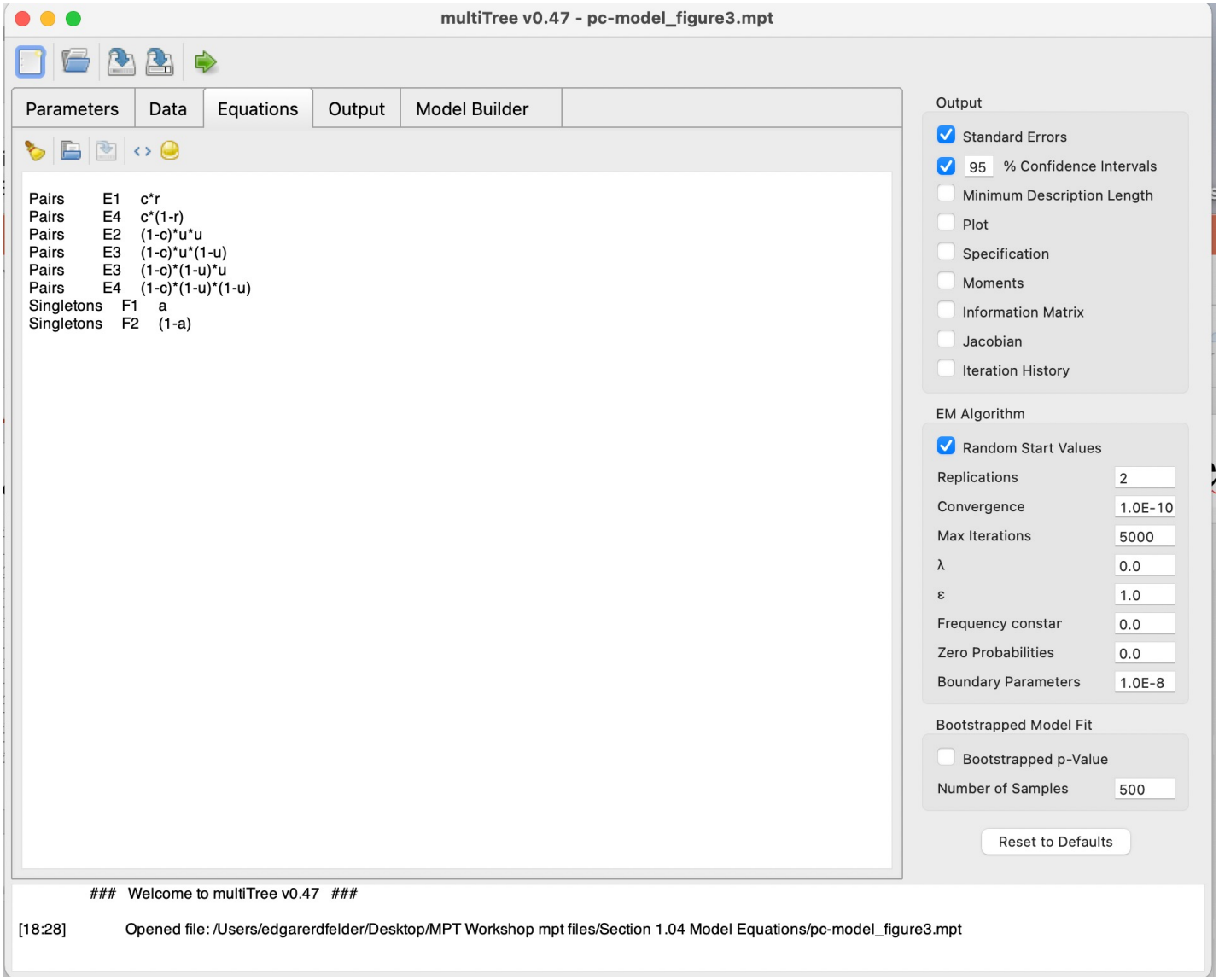


An example: The pair-clustering model

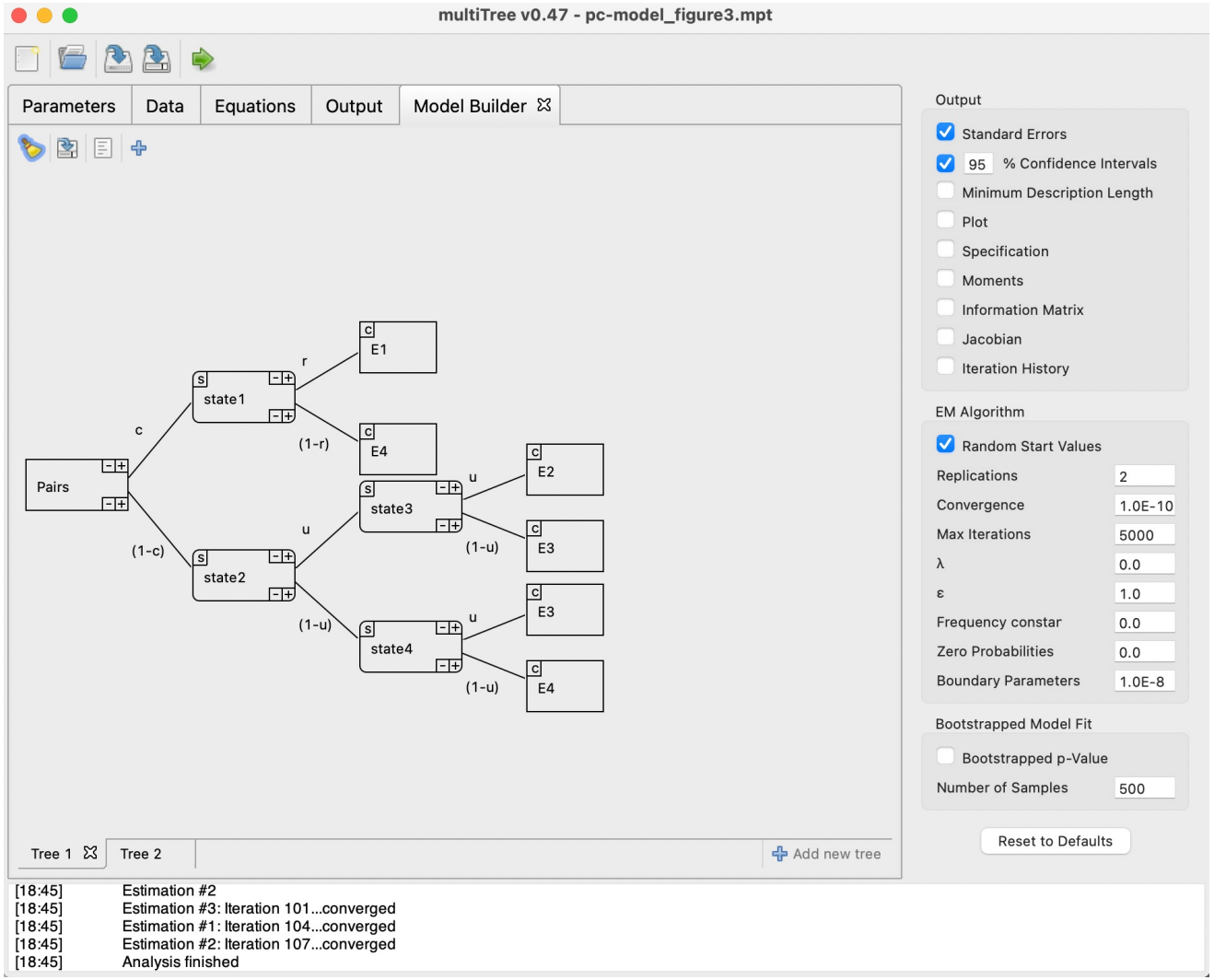


Pair-Clustering Model

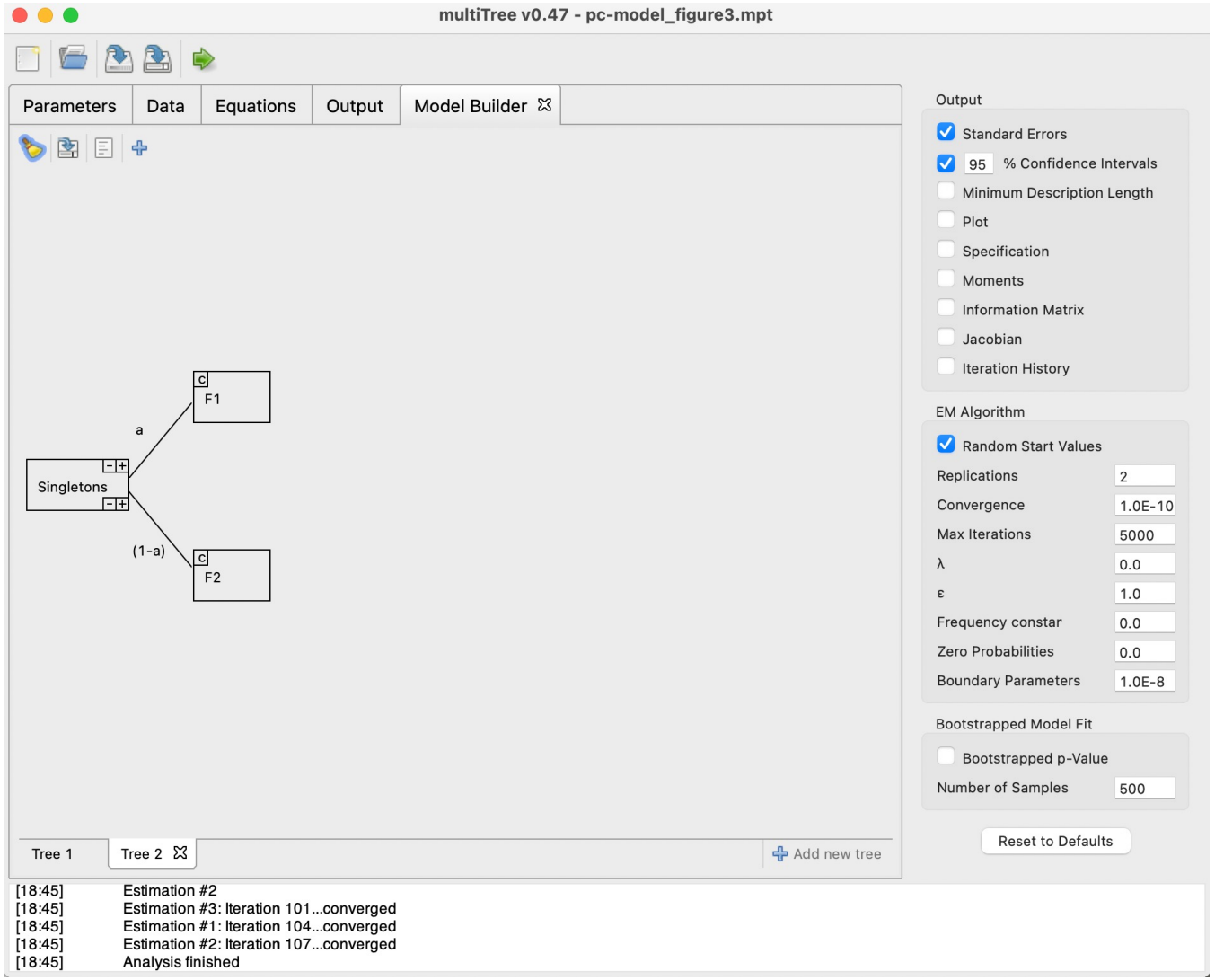
(Batchelder & Riefer, 1980,1986)



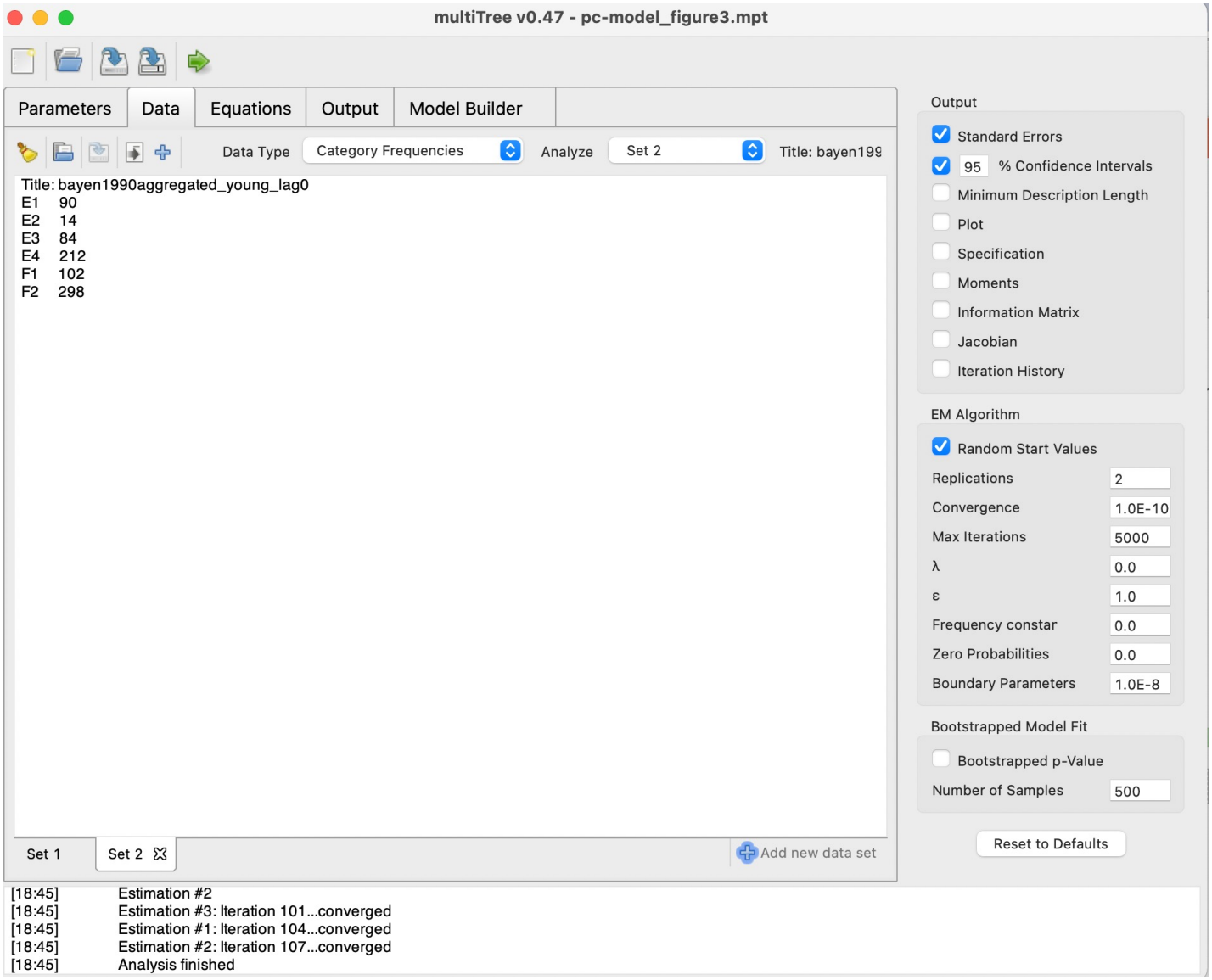
multiTree Model Builder: Pairs



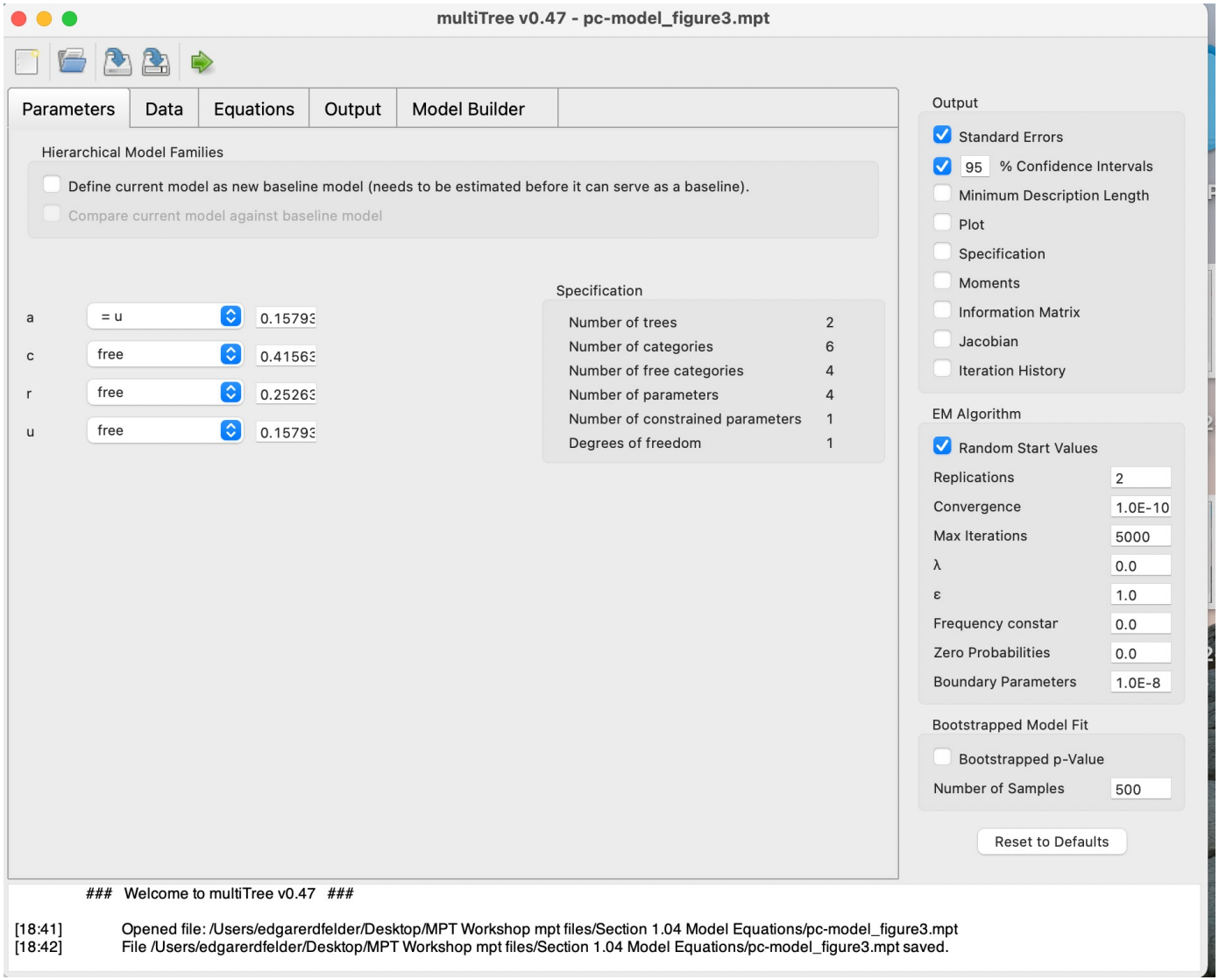
multiTree Model Builder: Singletons



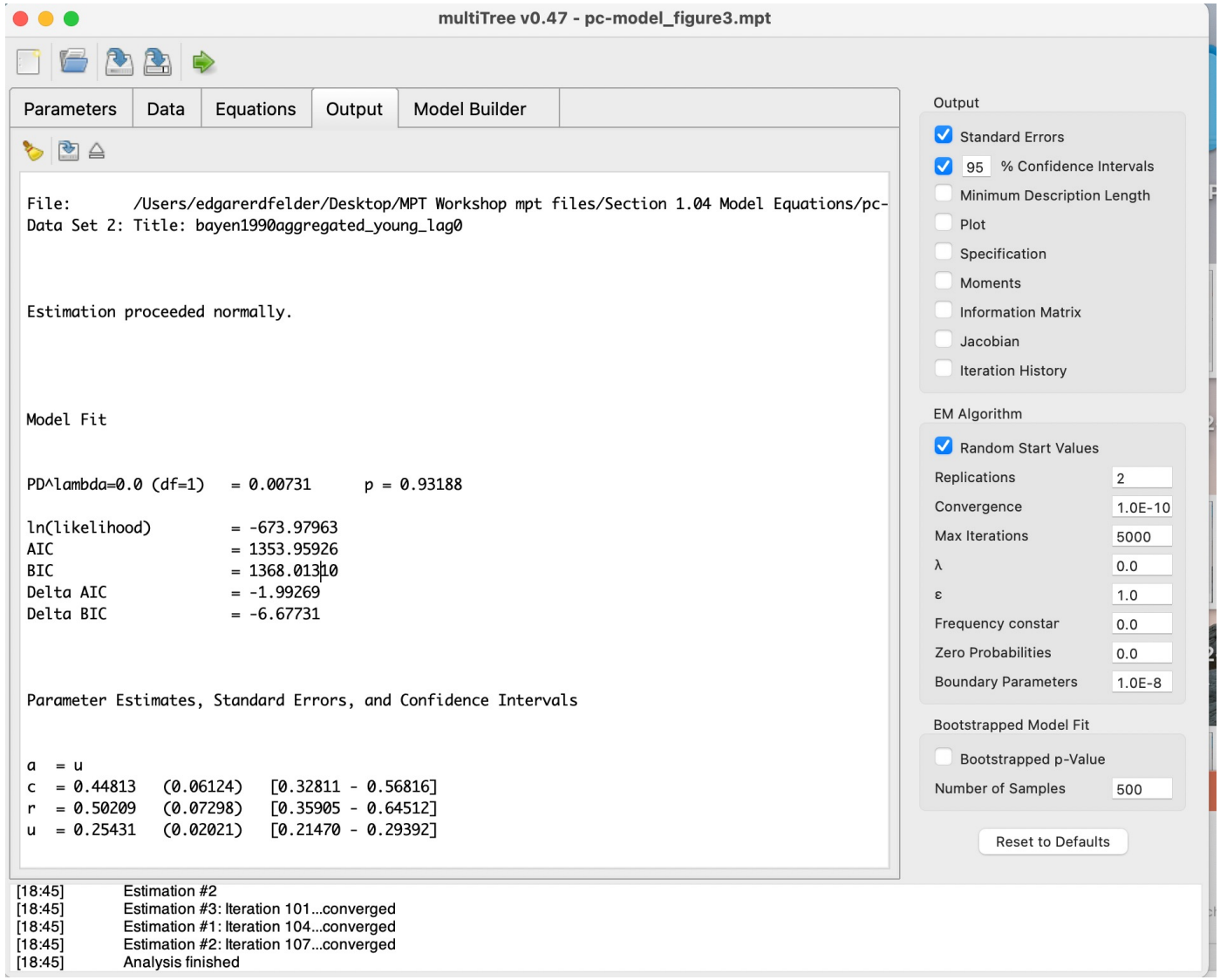
Data


multiTree v0.47 - pc-model_figure3.mpt
Parameters
Data
Equations
Output
Model Builder
Data Type
Category Frequencies
Analyze
Set 2
Title: bayen199
Title: bayen1990aggregated_young_lag0
E1 90
E2 14
E3 84
E4 212
F1 102
F2 298
Set 1
Set 2
Add new data set
Output
Standard Errors
95 % Confidence Intervals
Minimum Description Length
Plot
Specification
Moments
Information Matrix
Jacobian
Iteration History
EM Algorithm
Random Start Values
Replications 2
Convergence 1.0E-10
Max Iterations 5000
λ 0.0
ε 1.0
Frequency constar 0.0
Zero Probabilities 0.0
Boundary Parameters 1.0E-8
Bootstrapped Model Fit
Bootstrapped p-Value
Number of Samples 500
Reset to Defaults
[18:45] Estimation #2
[18:45] Estimation #3: Iteration 101...converged
[18:45] Estimation #1: Iteration 104...converged
[18:45] Estimation #2: Iteration 107...converged
[18:45] Analysis finished

Model definition and analysis



Output


multiTree v0.47 - pc-model_figure3.mpt
Parameters
Data
Equations
Output
Model Builder
File: /Users/edgarerdfelder/Desktop/MPT Workshop mpt files/Section 1.04 Model Equations/pc-
Data Set 2: Title: bayen1990aggregated_young_lag0
Estimation proceeded normally.
Model Fit
PD^lambda=0.0 (df=1) = 0.00731 p = 0.93188
ln(likelihood) = -673.97963
AIC = 1353.95926
BIC = 1368.01310
Delta AIC = -1.99269
Delta BIC = -6.67731
Parameter Estimates, Standard Errors, and Confidence Intervals
a = u
c = 0.44813 (0.06124) [0.32811 - 0.56816]
r = 0.50209 (0.07298) [0.35905 - 0.64512]
u = 0.25431 (0.02021) [0.21470 - 0.29392]
Output
Standard Errors
95 % Confidence Intervals
Minimum Description Length
Plot
Specification
Moments
Information Matrix
Jacobian
Iteration History
EM Algorithm
Random Start Values
Replications 2
Convergence 1.0E-10
Max Iterations 5000
λ 0.0
ε 1.0
Frequency constar 0.0
Zero Probabilities 0.0
Boundary Parameters 1.0E-8
Bootstrapped Model Fit
Bootstrapped p-Value
Number of Samples 500
Reset to Defaults
[18:45] Estimation #2
[18:45] Estimation #3: Iteration 101...converged
[18:45] Estimation #1: Iteration 104...converged
[18:45] Estimation #2: Iteration 107...converged
[18:45] Analysis finished

2.2) Practical exercises

- Estimate the pair-clustering model for young and old partipants jointly (lag 0 word pairs only)
- Does *c* differ significantly between age groups?
- Does *r* differ significantly between age groups?

2.3 Order constraints

Simple idea:

To impose the order constraint

$$c(\text{old}) \leq c(\text{young}),$$

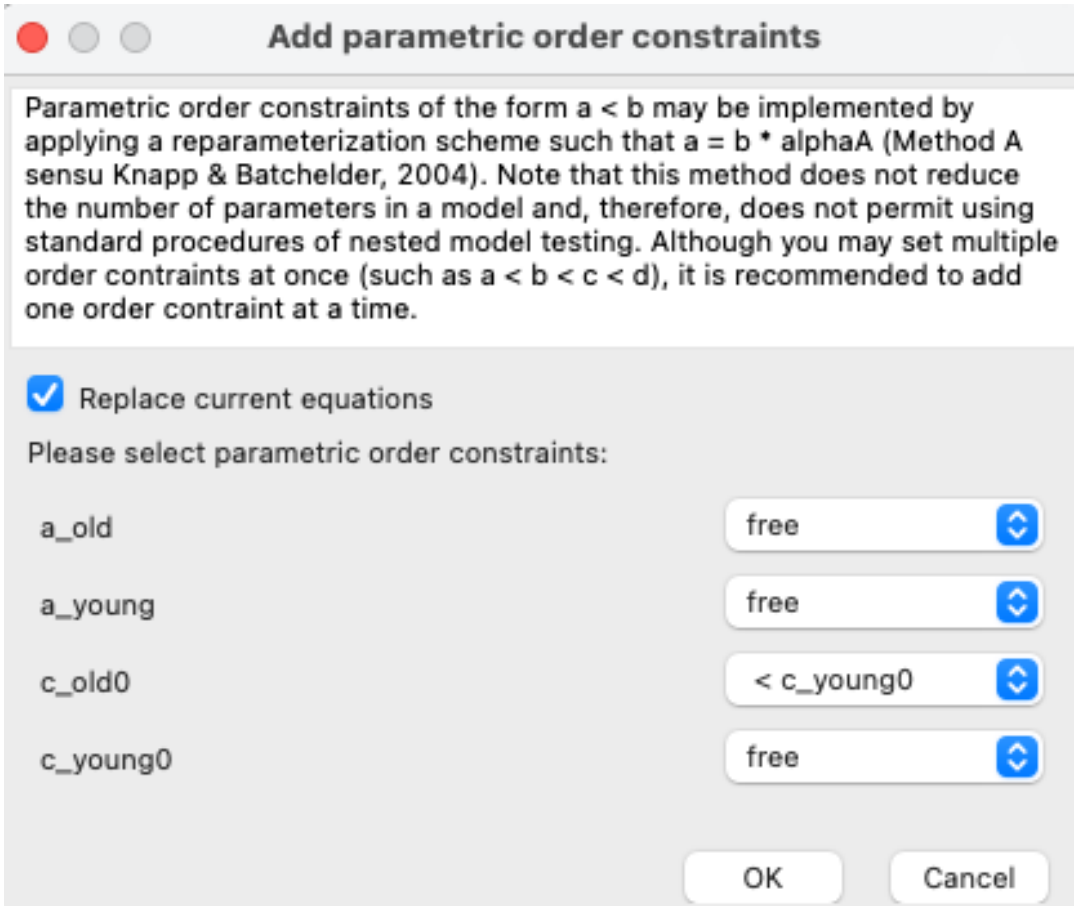
introduce a new MPT parameter s_c (called shrinkage parameter) and set

$$c(\text{old}) = s_c \cdot c(\text{young})$$

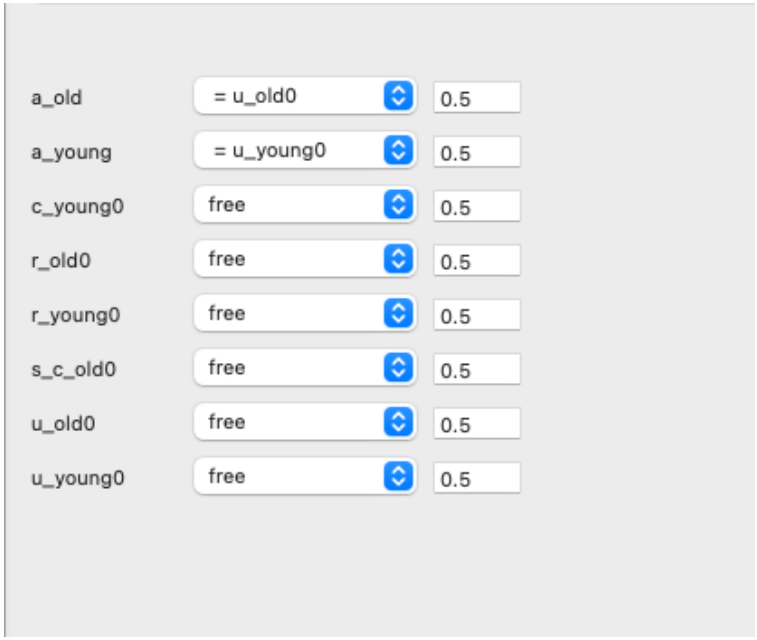
Model without order constraints


```
Model Fit


PD^lambda=0.0 (df=2)    = 0.15539       p = 0.92525

ln(likelihood)          = -1176.19517
AIC                     = 2364.39034
BIC                     = 2396.65690
Delta AIC               = -3.84461
Delta BIC               = -14.60013



Parameter Estimates, Standard Errors, and Confidence Intervals


a_old       = u_old0
a_young     = u_young0
c_old0      = 0.41563   (0.08733)   [0.24446 - 0.58679]
c_young0    = 0.44813   (0.06124)   [0.32810 - 0.56816]
r_old0      = 0.25263   (0.06107)   [0.13294 - 0.37232]
r_young0    = 0.50209   (0.07298)   [0.35905 - 0.64513]
u_old0      = 0.15793   (0.01738)   [0.12385 - 0.19200]
u_young0    = 0.25431   (0.02021)   [0.21470 - 0.29392]
```

Imposing order constraint on *c*



Model with order constraint on *c*




```
Model Fit


PD^lambda=0.0 (df=2)    = 0.15539       p = 0.92525

ln(likelihood)          = -1176.19517
AIC                     = 2364.39034
BIC                     = 2396.65690
Delta AIC               = -3.84461
Delta BIC               = -14.60013



Parameter Estimates, Standard Errors, and Confidence Intervals


a_old       = u_old0
a_young     = u_young0
c_young0    = 0.44813   (0.06124)   [0.32811 - 0.56816]
r_old0      = 0.25263   (0.06107)   [0.13294 - 0.37233]
r_young0    = 0.50208   (0.07298)   [0.35905 - 0.64512]
s_c_old0    = 0.92745   (0.23247)   [0.47183 - 1.38308]
u_old0      = 0.15793   (0.01738)   [0.12385 - 0.19200]
u_young0    = 0.25431   (0.02021)   [0.21470 - 0.29392]
```

2.4 Testing interactions

Simple and straightforward idea:

To test the H_0 that the relative age decline in cluster *storage c* and cluster *retrieval r* is the same (i.e., there is no interaction between memory process and age for lag 0 pairs), set

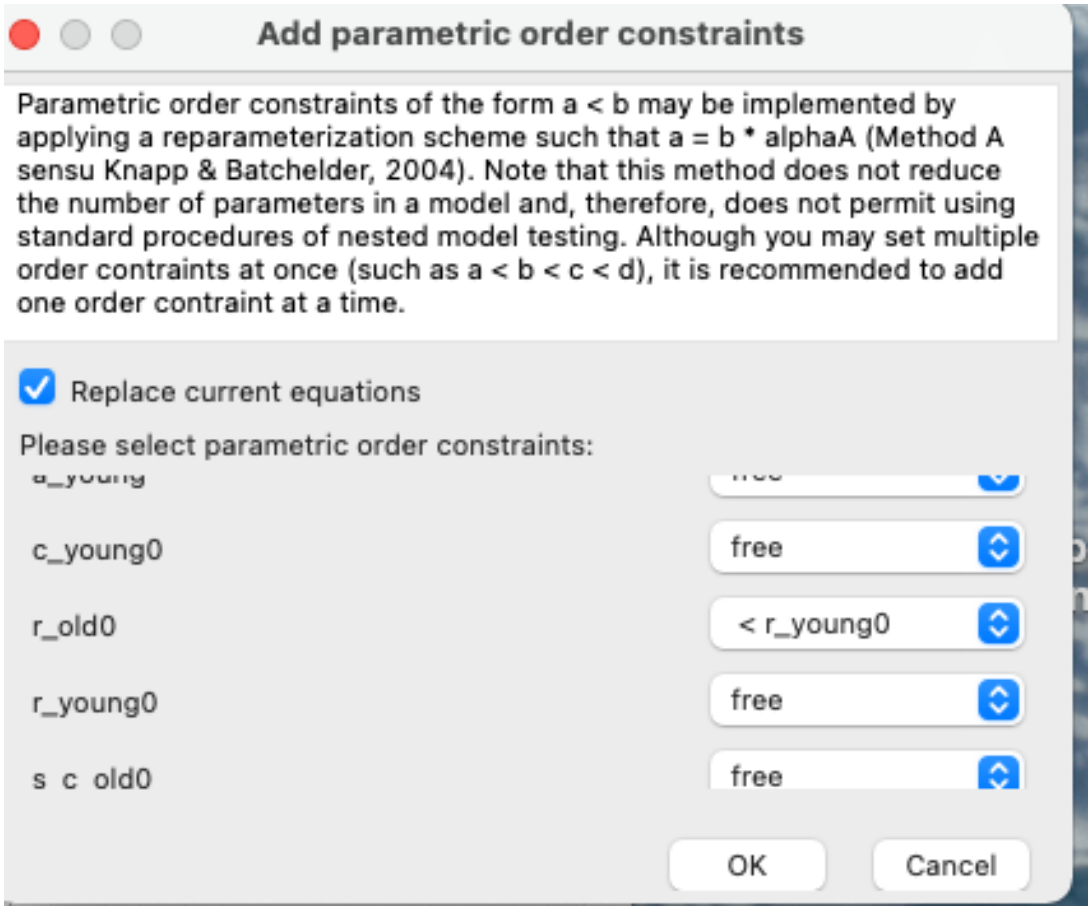
$$c(\text{old}) = s_c \cdot c(\text{young})$$

$$r(\text{old}) = s_r \cdot r(\text{young})$$

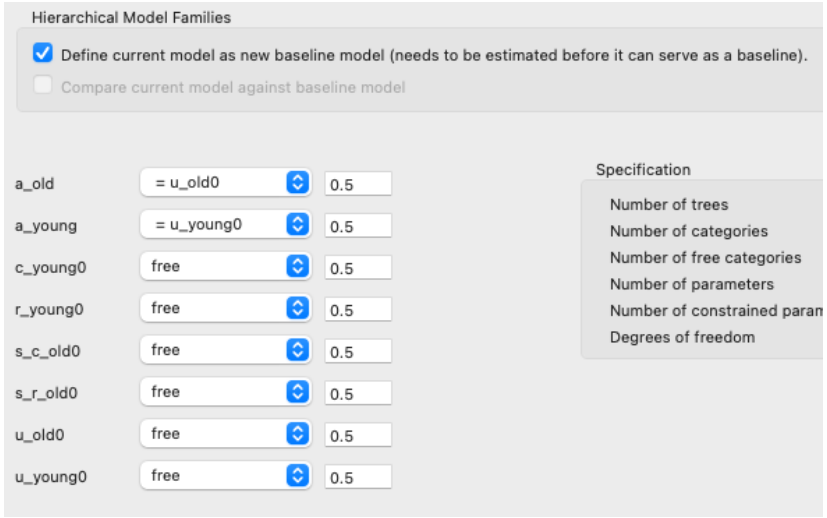
and test the equality constraint

$$H_0: s_c = s_r$$

Additional order constraint on *r*

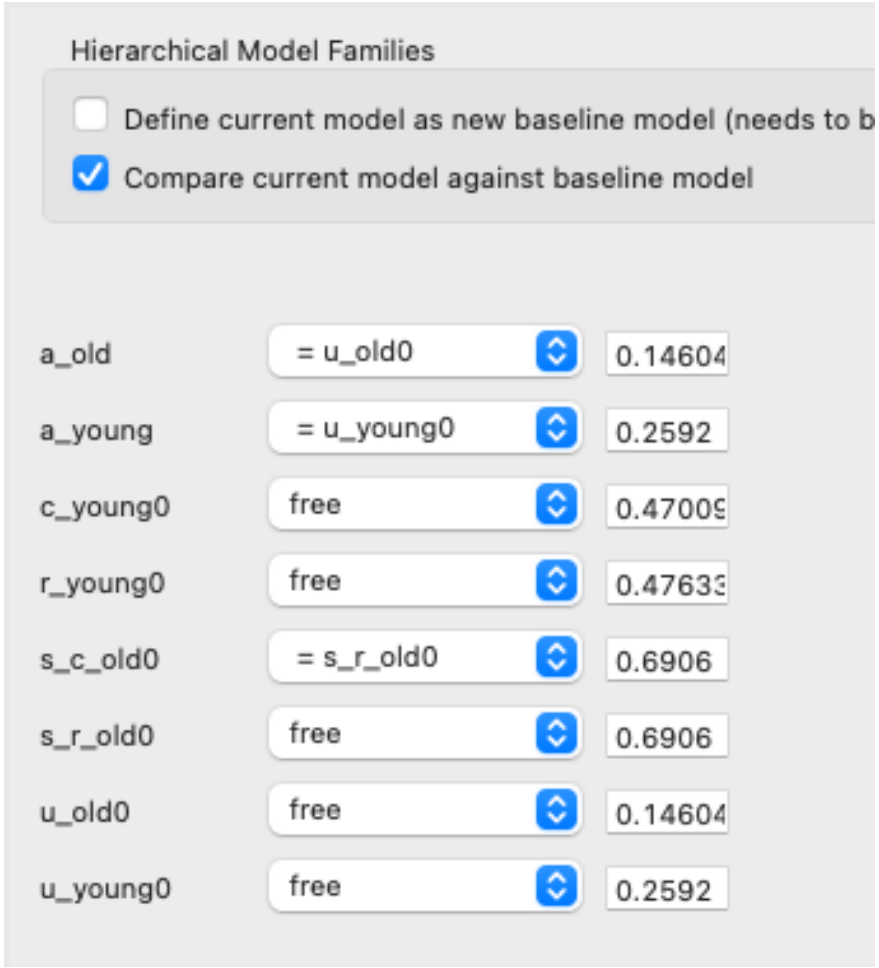


No constraint on *s* parameters




```
Model Fit


PD^lambda=0.0 (df=2)    = 0.15539       p = 0.92525

ln(likelihood)          = -1176.19517
AIC                     = 2364.39034
BIC                     = 2396.65690
Delta AIC               = -3.84461
Delta BIC               = -14.60013



Parameter Estimates, Standard Errors, and Confidence Intervals


a_old       = u_old0
a_young     = u_young0
c_young0    = 0.44813   (0.06124)   [0.32811 - 0.56816]
r_young0    = 0.50208   (0.07298)   [0.35905 - 0.64512]
s_c_old0    = 0.92745   (0.23247)   [0.47183 - 1.38308]
s_r_old0    = 0.50317   (0.14193)   [0.22500 - 0.78134]
u_old0      = 0.15793   (0.01738)   [0.12385 - 0.19200]
u_young0    = 0.25431   (0.02021)   [0.21470 - 0.29392]
```

Equality constraint on *s* parameters




```
Model Fit


PD^lambda=0.0 (df=3)    = 1.29956       p = 0.72924

ln(likelihood)          = -1176.76726
AIC                     = 2363.53452
BIC                     = 2390.42331
Delta AIC               = -4.70044
Delta BIC               = -20.83372



Difference to Baseline Model (Difference = Current - Baseline)


PD^lambda=0.0 (df=1)    = 1.14417       p = 0.28477

AIC difference          = -0.85583
BIC difference          = -6.23359


Parameter Estimates, Standard Errors, and Confidence Intervals


a_old       = u_old0
a_young     = u_young0
c_young0    = 0.47009   (0.05473)   [0.36283 - 0.57735]
r_young0    = 0.47633   (0.06177)   [0.35527 - 0.59739]
s_c_old0    = s_r_old0
s_r_old0    = 0.69060   (0.05922)   [0.57454 - 0.80667]
u_old0      = 0.14604   (0.01271)   [0.12112 - 0.17095]
u_young0    = 0.25920   (0.01965)   [0.22068 - 0.29771]
```

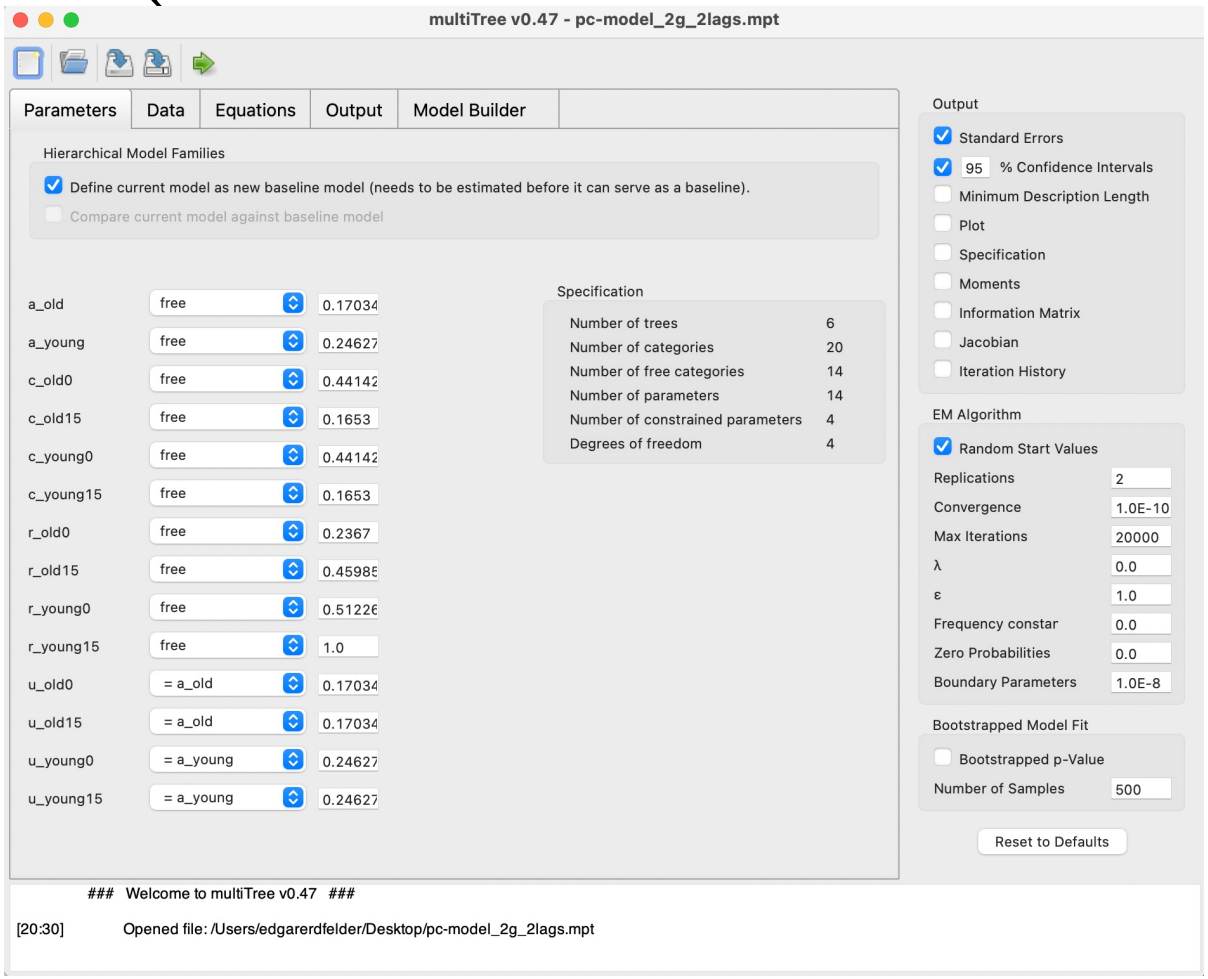
Conclusion

- There is no significant interaction effect between age (young vs. old) and memory process (cluster storage vs. retrieval) for lag 0 word pairs at least:
- $G^2(1) = 1.14, p = .28$
- This is better in line with the idea of a general cognitive age decline rather than a specific decline limited to retrieval.
- Note, however, that this insignificant outcome might be due to lack of statistical power.
- (We return to the power issue later.)

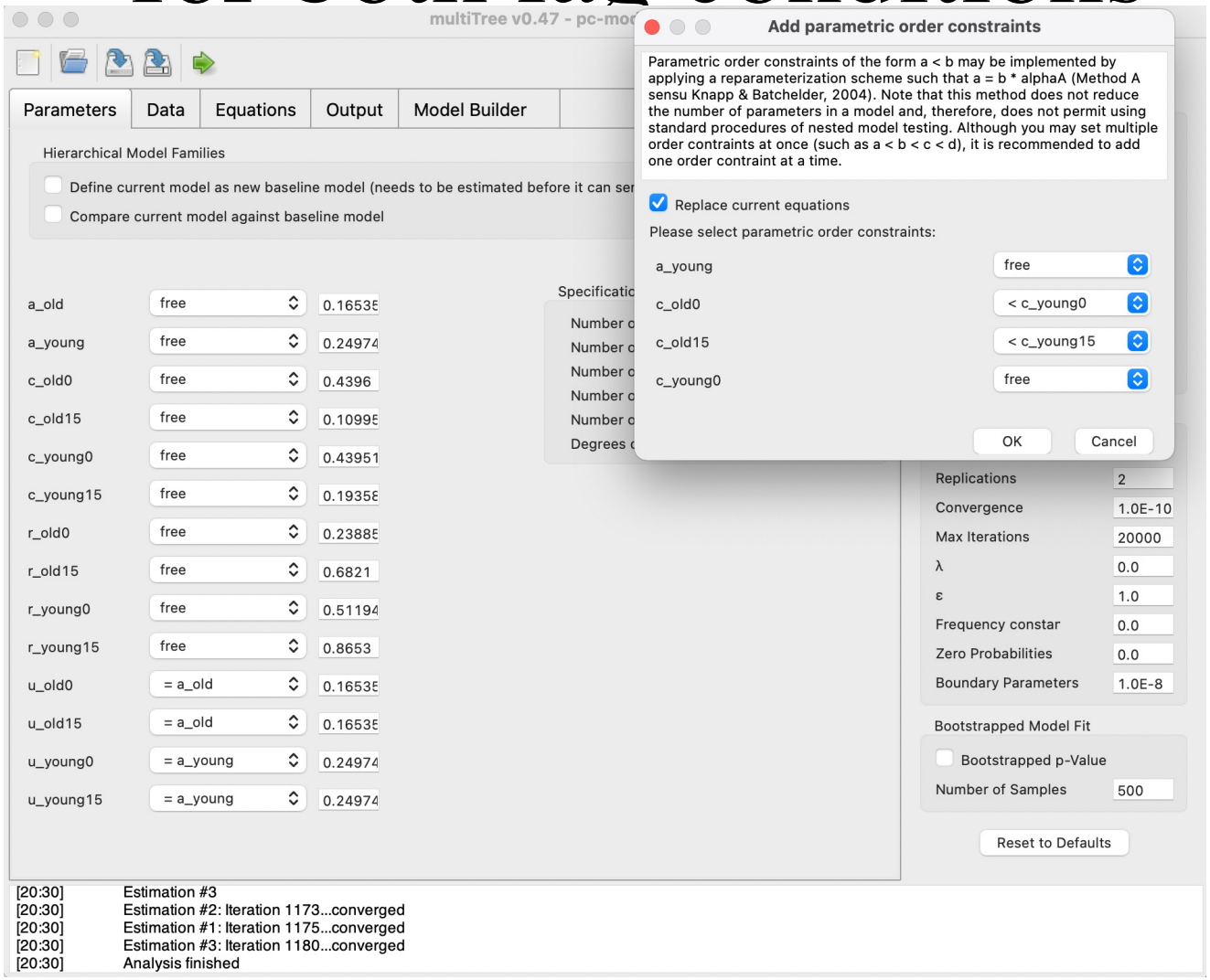
Further exercise

- The article by Schmidt, Erdfelder & Heck (2023, p. 11/12) extends this analysis to lag 15 presentation conditions for word pairs (with similar results).
- The corresponding mpt files are also available in Part 2 of the workshop zip file.

Model including lag 0 and lag 15 pairs (without order constraints)



Imposing order constraints on *c* for both lag conditions



Model with order constraints on c_0 and c_{15}